Pre-Operative Grade of Decompressing Systemic Venous Collaterals, But Not Jugular Venous Pressure, Predicts Short- and Medium-Term Outcome After Completion of the Total Cavopulmonary Connection

For pediatric patients with functionally single ventricles, cardiac magnetic resonance (CMR) imaging provides comprehensive interstage data before completion of total cavopulmonary connection (TCPC). Whether jugular venous pressure (JVP) measured at CMR adds prognostic power has not been evaluated.

After informed consent was given, imaging and outcomes were studied in all 147 patients undergoing pre-TCPC CMR and TCPC at the authors' institution between 2005 and 2017.

Patients under general anesthesia were scanned using a 1.5T scanner (1). The mean JVP was transduced in patients under the same anesthesia conditions.

CMR data included assessment ventricular function, through-plane quantitative flow volume from all great vessels and gadolinium-enhanced MR angiography. Two consecutive angiograms were acquired during a 20- to 30-s apneic pause. The systemic venous decompressing collateral grade (in short, superior vena cava or "SVC offload" grade) was evaluated from the late-phase angiogram and categorized using an ordinal grade by 2 experienced observers, using standard multiplanar viewing software (Figure 1). Testing by using 25 random cases showed acceptable intraobserver and interobserver agreement (kappa statistics 0.67 and 0.7, respectively; $p < 0.001$).

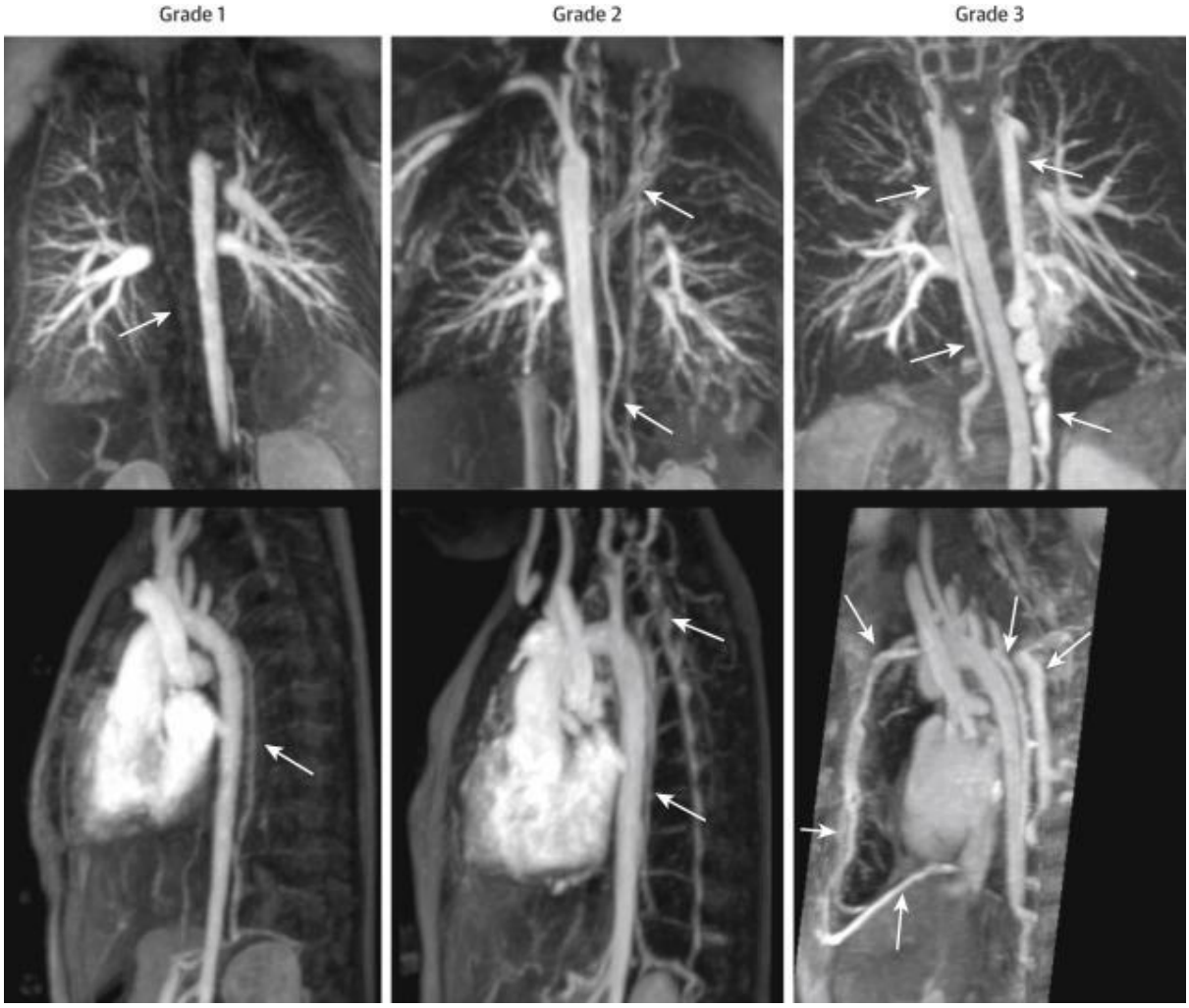

Figure 1. Grades of SVC Offload Channels Observed in Coronal and Sagittal Views Using Late Phase 3D CMR Angiography

The **arrows** denote systemic venous decompressing collateral channels (SVC offload) Grade 1 shows only a few, small SVC offload channels, characterized by a narrow, recannulated azygos vein, and small thoracic and upper abdominal paravertebral venous plexus channels. Grade 2 shows a moderate quantity of SVC offload channels, including a recannulated azygos vein (>3-mm diameter) and/or hemiazygos channels and enlarged thoracic paravertebral venous plexus channels. Grade 3 shows multiple large SVC offload channels consisting of dilated and tortuous recannulated azygos or hemiazygos channels and prominent thoracic paravertebral venous plexus channels, with additional mediastinal and anterior channels (distended internal mammary vein connecting to the IVC and left superior intercostal channels to hemiazygos or pulmonary venous system are evident). 3D = 3-dimensional; CMR = cardiac magnetic resonance; IVC = inferior vena cava; SVC = superior vena cava.

Outcome was evaluated for 1) hospital length of stay (LOS); 2) “composite early outcome,” that is, determining the need for rescue fenestration,

emergency TCPC takedown, or death <30 days after TCPC; and 3) “composite medium-term outcome,” that is, death or transplantation >30 days after TCPC or hemodynamic TCPC failure.

Composite early outcome was tested using univariate logistic regression or chi-square test with testing for linear trends. Univariate Cox proportional hazard tested medium-term outcome. Univariate hazard ratios (HRs) were standardized and are shown with confidence intervals (CIs). Spearman’s correlation was used to test associations.

All 147 patients underwent TCPC, using an extracardiac conduit at a median of 3.9 years of age (range: 2.1 to 10.5 years); 64 patients (44%) underwent fenestration at the time of TCPC, at the surgeon’s discretion.

A total of 74 patients (50%) had a functionally dominant right ventricle (RV); and 28 patients (19%) had some preserved native forward flow. Mild-to-moderate arch obstruction occurred in 40 patients (27%), and branch pulmonary artery (PA) stenosis or hypoplasia was found in 56 patients (38%). Median ventricular ejection fraction was 56% (range: 36% to 77%). Median JVP was 11.0 mm Hg (range: 5 to 20 mm Hg).

A total of 79 patients (54%) had minor visible SVC offload collaterals (grade 1); 29 (20%) had grade 2 offload, and 39 (26%) had grade 3.

SVC offload grade correlated negatively with pre-TCPC SaO_2 ($r = -0.19$; $p < 0.04$).

The median hospital LOS was 12 days (range: 4 to 110 days). LOS correlated only with SVC offload ($r = 0.26$; $p < 0.001$), systemic pulmonary collateral flow($r = 0.23$; $p < 0.01$), McGoon ratio ($r = -0.16$; $p = 0.047$), and dominant RV morphology ($r = -0.19$; $p = 0.034$). JVP did not predict LOS.

Only SVC offload grade predicted the composite early outcome of rescue fenestration (n = 4), emergency take-down (n = 1), or death (n = 1) ($p < 0.03$).

Median post-TCPC follow-up was 5.4 years (range: 0.3 to 12 years). Eight patients were lost to follow-up. Three patients died from TCPC failure, and 1 patient received a transplant. Eight of the 133 surviving patients followed met criteria for TCPC failure.

The predictors of >30-day (median-term) death, transplantation, or TCPC failure were SVC offload grade (HR: 3.3; 95%: 1.5 to 7.0; $p < 0.01$), lower pre-TCPC SaO_2 (HR: 0.5; 95% CI: 0.3 to 0.9; $p = 0.02$), and dominant RV

morphology (HR: 9.8; 95% CI: 1.3 to 76.0; p < 0.03). JVP did not predict this composite outcome.

The authors concluded that JVP did not predict early or medium post-TCPC outcome, which is supported by cardiac catheterization studies (2) and is probably because SVC offloading allows venous decompression. The SVC offload grade was a reliable marker for LOS and short- and medium-term TCPC outcomes.

Other investigators have demonstrated decompressing collaterals from superior to inferior vena caval systems, associated with cavopulmonary shunt, particularly with PA obstruction or elevated pulmonary vascular resistance 3, 4. Once the TCPC is formed, systemic venous decompression is not possible, and consequently, PA pressure becomes elevated.

The grade of SVC offload burden may provide a valid and reliable decision tool with which to guide further investigation, clinical risk management, and hospital resource allocation for these patients.

References

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